to designate both generic and specific embodiments of the substrate is not inconsistent. Applicants respectfully request that the Examiner withdraw the objections under 37 CFR 1.84(p)(4) to the drawings for the foregoing reasons.

On page 8, line 24, the sentence "Ohmic layer 22A provides ohmic contact to semiconductor 21." was inserted between "... 22C" and "A barrier ...". This addition is not new matter and is clearly supported in the specification, claims and figures, as originally filed. Page 8, line 23 clearly indicates that the figure is an alternative embodiment. Comparing Figure 1 to Figure 3 (proposed to be renamed as Figure 3 and referred to as Figure 4 in the specification as originally filed), reference characters "10" & "20" both refer to semiconductor devices as reference characters "12A" & "22A" both refer to ohmic layers. In Figure 1, reference character "11" refers to a semiconductor and it is clear that reference character "21" in Figure 3 also refers to a semiconductor as ohmic layer "22A" is in contact with the structure of semiconductor device 20 that is represented by reference character "21". Reference character "hυ" is well known and refers to photon energy (see Attachment D); one of ordinary skill in the art at the time the invention was made would look at the figures of the application and recognize the path of a photon, designated by "hυ", as it is reflected between contacts and semiconductor layers.

In the figures, the labels of Figures 3 & 4 were switched. The labels of the two figures were inadvertently switched at the time the application was filed. The changes merely reflect the accurate descriptions of the two figures in pages 5-10 of the specification, as originally filed. No new matter is added. Applicants respectfully request that the Examiner withdraw the objections to the drawings for the foregoing reasons.

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The Examiner objected to the specification on the basis that:

> on page 6, line 11, "(linear I-V)" is missing some simple description about I and V, and their relationship to each other. On page 9, line 12 "current LED structure" is not clear. The

word "current" is indicating the invention of this application or a current existing LED structure in the market. On page 6, line 7, "the semiconductor structure" should be --semiconductor structure--. On page 7, line 30, "contacts.." should be --contacts.--. On page 9, line 1, "the ohmic 22A and reflector layers 22C" should be --the ohmic layer 22A and the reflector layer 22C--, etc. The specification is replete with such errors on pages 8, 9, and 10 of the specification, and each of them should be corrected.
Appropriate correction is required.

Applicants have reviewed the specification and made the grammatical changes requested by the Examiner. The relationship between I and V is well-known and can be found in any basic physics book. The Examiner takes the term "current LED structure" out of context as the term "vertical current" refers to the path of the current in the LED.

Claims 1, 8 & 11 were objected to because of informalities. The Examiner stated that:

> in claim 1, line 2 and claim 11, line 2, "at least one p and" should be --at least one p-type and-- and in claim 11, line 2, is missing a word --and-- after the semicolon. In claim 8, line 1, "whereinthe" should be --wherein the--. Appropriate correction is required.

In response, Applicants have reviewed the claims and made the grammatical changes requested by the Examiner.

Claims 1, 4, 7, 8, 11, 14 & 17 are rejected under 35 U.S.C. §102(b) as being anticipated by Schetzina. In the Office Action dated March 28, 2001, the Examiner stated that:

> [f]igure 27 of Schetzina shows a "light emitting device" (120) comprising a "heterostructure" (11) of semiconductor materials having at least one p-type layer (17) and one n-type layer (16), and the p-type layer (17) and the n-type layer (16) have p and n contacts. The p contact is electrically connected to the p-type layer and the n contact is electrically connected to the n-type layer, wherein one of the p and n contacts is a multi-layer contact having at least one ohmic layer (102 for n-type contact layer and 19 for p-type contact layer) and one reflector layer (13 and column 21, lines 14-19).

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> Regarding claims 4 and 14, Schetzina discloses the multi-layer contact has a barrier layer (18 in Fig. 27) interposing the ohmic contact layer and the reflector layer.
>
> Regarding claims 7 and 17, Schetzina discloses the reflector layer is selected from a group that includes Al, Cu, Rh, Pd, and Au (column 18, lines 48-50).
>
> Regarding claim 8, in Fig. 27, reference character (102) and reference character (19) clearly show that the p and n contacts are on opposing faces of the heterostructure.
>
> Regarding claim 11, Fig. 27 of Schetzina shows a "light emitting device" (120) comprising a "GaN-based heterostructure" (11 and column 22, lines 26-30 (Group III-V materials includes Ga and blue light is indicating N)) of semiconductor materials having at least one p-type layer (17) and one n-type layer (16), and the p-type layer (17) and the n-type layer (16) have p and n contacts. The p contact is electrically connected to the p-type layer and the n contact is electrically connected to the n-type layer, wherein one of the p and n contacts is a multi-layer contact having at least one ohmic layer (102 for n-type contact layer and 19 for p-type contact layer) and one reflector layer (13 and column 21, lines 14-19).

Applicants respectfully traverse the Examiner's rejections of Claims 1, 4, 7, 8, 11, 14 & 17 and contend that Schetzina does not anticipate the claimed invention. The Examiner rejected Claims 1, 4, 7, 8, 11, 14 & 17 on the basis that Schetzina disclosed the invention as outlined above. MPEP 706.02 [Rejection on Prior Art] clearly states that rejections under 35 USC 102 require that "the reference must teach every aspect of the claimed invention either explicitly or impliedly. Any feature not directly taught must be must be inherently present." Schetzina fails to teach every aspect of the claimed invention, either explicitly or impliedly, for the reasons discussed below.

With respect to Figure 27 of Shetzina, the figure shows that the ohmic contact (a.k.a. electrical heterostructure 12) comprises only layers 18, 19 which are in contact with an ohmic electrode 13, which also doubles as the reflecting layer. However, not only is electrode 13 not part of the electrical heterostructure 12, the electrical heterostructure is made of

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semiconductor materials rather than metallic materials. In the instant invention, the reflecting layer is part of the ohmic contact and the ohmic contact is made of metallic layers.

With respect to Claims 4 and 14, the Examiner misconstrues layer 18, which is part of the ohmic contact, as a barrier layer. Figure 27 of Schetzina does not show a barrier layer nor does Schetzina mention any problem of device-degrading inter-metallics created by ohmic and reflector layer diffusion (see page 4, lines 22-26 of the Applicants' specification) to suggest the use of a barrier layer. Schetzina does not discuss layer 18 as acting as a barrier layer.

With respect to Claims 7 and 17, Schetzina (col. 18, lines 48-50) fails to disclose the use of every member of the group; Cu, Rh and Pd are not disclosed.

With respect to Claim 11, Schetzina fails to disclose the use of GaN and only refers to III-V materials as high brightness red LEDs (e.g., "High-brightness red LEDs, composed of III-V materials (GaAsP junctions on GaP substrates) are already available." Col. 22, lines 28-30). [Emphasis added.] In fact, Schetzina is focused on Group II-VI blue light sources; not III-V materials. The Examiner is apparently using the "blue light" produced by the disclosed Group II-VI materials as the basis for improper hindsight. This rejection also fails to disclose the claimed invention in that, as stated above, the ohmic contact (a.k.a. electrical heterostructure 12) comprises only layers 18, 19 which are in contact with an ohmic electrode 13, which also doubles as the reflecting layer. However, electrode 13 is not part of the electrical heterostructure 12. In the instant invention, the reflecting layer is part of the ohmic contact.

Schetzina does not teach all the features of Claims 1, 4, 7, 8, 11, 14 & 17. Thus, these claims are allowable. Therefore, for the above reasons, Applicant respectfully requests reconsideration and withdrawal of the rejections of Claims 1, 4, 7, 8, 11, 14 & 17 which were rejected under 35 U.S.C. §102(b) as being anticipated by Schetzina.

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Claims 2 and 12 are rejected under 35 U.S.C. §103(a) as being unpatentable over Schetzina in view of Tischler. With respect to Claims 2 and 12, the Examiner stated that:

> Schetzina discloses the claimed invention except the reflectivity of the multi-layer contact of the light emitting device, which is greater than 75%. However, Tischler discloses the reflectivity of the multi-layer contact having a "peak reflectivity [] measured to be 80% at 442nm"(column 11, lines 47-52). Thus, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Schetzina by increasing the reflectivity of the multi-layer contact to be greater than 75%. The ordinary artisan would have been motivated to modify Schetzina in the manner described above for at least the purpose of increasing a light output and light extraction efficiency (column 10, lines 46-61 and column 4, lines 49-54).

In response, Applicants respectfully contend that Schetzina does not render the claimed invention obvious as the rejection is procedurally and substantively inadequate. In a rejection based upon obviousness, the "critical inquiry is whether 'there is something in the prior art as a whole to suggest the desirability, and thus the obviousness of making the combination.'" Fromson v. Advance Offset Place, Inc., 755 F.2d 1549, 1556, 225 USPQ 26, 31 (Fed. Cir. 1985) *quoting* Lindemann Maschinenfabrik GMBH v. American Hoist & Derrick Co., 730 F.2d 1453, 1452, 221 USPQ 481, 488 (Fed. Cir. 1984).

In Ruiz v A.B. Chance Co., 234 F.3d 654 (Fed. Cir. 2000), it was held that "while the references need not expressly teach that the disclosure contained therein should be combined with another, see Motorola, Inc. v. Interdigital Tech. Corp., 121 F.3d 1461, 1472, 43 USPQ2d 1481, 1489 (Fed. Cir. 1997), *the showing of combinability must be "clear and particular."* In re Dembiczak, 175 F.3d at 999, 50 USPQ2d at 1617. [Emphasis added]. In the instant office action, the Examiner's basis for combining Schetzina with Tischler is far from "clear and particular." Schetzina does not suggest the desirability of modifying Schetzina in the manner claimed by the Examiner. In fact, the Examiner admits that Schetzina does not disclose a

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contact with a reflectivity greater than 75%. Even Tischler indicates that the reflectivities obtained were only due to the presence of a Bragg Mirror placed UNDER the LED structure (col. 10, lines 45-48). Furthermore, in the instant application, it is the multi-layer contact which has a reflectivity greater than 75%; the Bragg mirror is not a multi-layer contact. Additionally, Schetzina teaches the use of II-VI materials while Tischler teaches away from II-VI materials (col. 1, lines 30-53: discussing the problems and disadvantages of II-VI materials) while the instant application is directed to III-V materials. Accordingly, there is no teaching or motivation to suggest to one skilled in the art the desirability to modify Schetzina in the manner claimed by the Examiner.

Furthermore, the "statute, §103, requires much more, i.e., that it would have been obvious to produce the claimed invention at the time it was made without the benefit of hindsight." Orthokinetics, Inc. v. Safety Travel, Chairs, Inc., 806 F.2d 1565, 1575, 1 USPQ2d 1081, 1087 (Fed. Cir. 1986). "When prior art references require selective combination by the court to render obvious a subsequent invention, there must be some reason for the combination other than the hindsight gleaned from the invention itself." Interconnect Planning Corp. v. Feil, 774 F.2d 1132, 1143, 227 USPQ 543, 551 (Fed. Cir. 1985) *citing* ACS Hosp. Sys., Inc. v. Montefiore Hosp., 732 F.2d 1572, 1577 & n.14, 221 USPQ 929, 933 & n.14 (Fed. Cir. 1984). Applicants believe the motivation to modify Schetzina with Tischler is derived from Applicants' invention since there is no suggestion in the cited reference for the desirability of modifying Schetzina in the manner described by the Examiner.

Additionally, the Examiner's conclusory and argumentative statements that something is obvious to one of ordinary skill in the art is not supported by any evidence as the Examiner has failed to establish just what is the ordinary level of skill in the art to support his contentions. Each art has its own level of ordinary skill. The hypothetical person of ordinary skill in the art to which the claimed subject matter pertains, would, of necessity, have the

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capability of understanding the scientific and engineering principles applicable to the pertinent art. His knowledge rests somewhere between that possessed by a layman and that possessed by an expert. *Ex parte Hiyamizu*, 10 USPQ 2d 1393, 1394 (BPAI 1988). A patent examiner <u>must</u> ascertain what would have been obvious to one of ordinary skill in the art at the time the invention was made and not to the inventor, a judge, a layman, those skilled in remote arts, or to geniuses in the art at hand. *Environmental Design, Ltd. v. Union Oil Co.*, 1713 F.2d 693, 697, 218 USPQ 865, 868-9 (Fed. Cir. 1983). In the instant rejection, the Examiner failed to perform this inquiry and, therefore, has no basis for claiming that a person of ordinary skill in the art at the time the invention was made would have been motivated to modify Schetzina in view of Tischler.

The Examiner has failed to provide proper support for the rejections and has failed to state the rejections with the required clearness and particularity. MPEP 706.02(j) [Contents of a 35 USC 103 Rejection] requires that in order for an Examiner to:

> establish a *prima facie* case of obviousness, three basic criteria must be met. First, *there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings.* Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all claim limitations. The teaching or suggestion to make the claimed combination and reasonable expectation of success must both be found in the prior art and not based on applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991). See MPEP 2143-2143.03 for decisions pertinent to each of these criteria.
>
> *The initial burden is on the examiner to provide some suggestion of the desirability of doing what the inventor has done.* "To support the conclusion that the claimed invention is directed to obvious subject matter, either the references must expressly or impliedly suggest the claimed invention or the examiner must present a convincing line of reasoning as to why the artisan would have found the claimed invention to have been obvious in light of the teachings of the references." *Ex parte Capp*, 227 USPQ 972, 973 (Bd. Pat. App. & Inter. 1985).

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> See MPEP 2144-2144.09 for examples of reasoning supporting obviousness rejections. [Emphasis added.]

Applicants respectfully contend that the modification of Schetzina in view of Tischler fails to meet there requirements and that the modification of Schetzina is based on improper hindsight, with Applicants' own specification being used as the guide to combine Schetzina and Tischler. Therefore, Applicants respectfully request reconsideration and withdrawal of the rejection to Claims 2 and 12 under 35 U.S.C. § 103(a).

Claims 3 and 13 are rejected under 35 U.S.C. §103(a) as being unpatentable over Schetzina in view of Sugiura et al. With respect to Claims 3 and 13, the Examiner stated that:

> Schetzina discloses the claimed invention except the contact resistance of the multi-layer contact of the light emitting device, which is less than 0.01 Ω-cm^2. However, Sugiura et al. discloses the contact resistance of the multi-layer contact having "about 0.1 Ω-cm^2 is reduced to 0.001 Ω-cm^2" (column 5, lines 27-32). Thus, it would have been obvious to one of ordinary skill in the art at the same time the invention was made to modify Schetzina by decreasing the contact resistance of the multi-layer contact to be less than 0.01 Ω-cm^2 as taught by Sugiura et al. The ordinary artisan would have been motivated to modify Schetzina in the manner described about for at least the purpose of improving performance of the light-emitting device by decreasing the contact resistance in the multi-layer contact.

Applicant respectfully traverses the rejections of Claims 3 and 13. Again, the Examiner fails to provide a 'clear and particular's reason for combining the references. Sugiura et al. fails to disclose the use of a multi-layer contact and Schetzina fails to disclose a motivation to reduce contact resistance. It is also respectfully suggested that the process disclosed in Sugiura et al. for III-VI materials for reducing contact resistance is inappropriate for Schetzina which is directed to II-VI materials. Therefore, Applicants respectfully request reconsideration and withdrawal of the rejections to Claims 3 and 13 under 35 U.S.C. § 103(a).

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Claims 5, 10 and 15 are rejected under 35 U.S.C. §103(a) as being unpatentable over Schetzina in view of Nakagawa et al. With respect to Claims 5, 10 and 15, the Examiner stated that:

> [r]egarding claims 5 and 15, Schetzina discloses the claimed invention except the thickness of the reflector layer, which is greater than 500 angstroms. However, Nakagawa et al. discloses the thickness of the reflector layer to be "(Ti/Pd/Ag (400nm/200nm/1 μm thick))" (column 19, lines 45-48). Thus, it would have been obvious to one of ordinary skill in the art at the same time the invention was made to modify Schetzina by increasing the thickness of the reflector layer to be greater than 500 angstroms. The ordinary artisan would have been motivated to further modify Schetzina in the manner described about for at least the purpose of increasing the reflection and to have a high quality semiconductor layer (column 19, lines 57-59).
>
> Regarding claim10, a difference between Schetzina and the claimed invention is that the reflector layer is Ag. However, Nakagawa et al. discloses the reflector layer using a "silver after being burned also function as a back-surface electrode and a back-surface reflection layer" (column 14, lines 1-2). Thus, it would have been obvious to one of ordinary skill in the art at the same time the invention was made to modify Schetzina by using Ag for the reflector layer as taught by Nakagawa et al. The ordinary artisan would have been motivated to modify Schetzina in the manner described about for at least the purpose of reducing the reflection loss of an incident light (column 14, lines 11-12).

Applicant respectfully traverses the rejections of Claims 5, 10 and 15. While the Examiner states that "the ordinary artisan would have been motivated to further modify Schetzina in the manner described about for at least the purpose of increasing the reflection and to have a high quality semiconductor layer (column 19, lines 57-59)" (see above), there is no such motivation, stated either explicitly or implicitly in either Schetzina or Nakagawa et al. Additionally, the reflector layer in Nakagawa et al. is directed to a collecting contact for a solar cell that seeks to maximize reflection that keeps light internal to the device while an LED seeks to maximize reflection so that more light escapes from the LED. The purpose of

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the LED contact is to power the LED and reflect light out of the LED while the contact of the solar cell is directed towards collecting energy. The so-called reflector layer in Nakagawa et al. is not a reflective contact in the sense of the LED but a collecting electrode for a solar cell (col. 19, lines 45-48).

While the Examiner states that the "ordinary artisan would have been motivated to modify Schetzina in the manner described about for at least the purpose of reducing the reflection loss of an incident light (column 14, lines 11-12)" (see above), there is no such motivation, stated either explicitly or implicitly in either Schetzina or Nakagawa et al. In fact, Nakagawa et al. explicitly states that this alleged motivation for using Nakagawa et al. to modify Schetzina is directed towards the texturing of the semiconductor layer, not the back-surface contact/reflector layer. The Examiner is using an unrelated motivation (i.e., the motivation for texturing the semiconductor layer; col. 14, lines 11-12) as the motivation for doing something completely unrelated (i.e., using Ag as a back-surface reflection layer). In fact, the so-called motivation for texturing the semiconductor layer in the solar cell is to REDUCE the reflection loss of an incident light (i.e., prevent the light from escaping the solar cell); the opposite goal of the reflection layer in the LED which is to maximize the amount of light being emitted from the LED.

Therefore, Applicants contend that the rejections of Claims 5, 10 and 15 by Schetzina in view of Nakagawa et al. are improper and respectfully request reconsideration and withdrawal of the rejections to Claims 5, 10 and 15 under 35 U.S.C. § 103(a).

Claims 6 and 16 are rejected under 35 U.S.C. §103(a) as being unpatentable over Schetzina. With respect to Claims 6 and 16, the Examiner stated that:

> Schetzina discloses the claimed invention except for the thickness of the ohmic contact layer, which is less than 200 angstroms. However, he discloses the thickness of the ohmic contact layer to be "about 1000 angstroms." in the specification

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> (column 6, line 13). Thus, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the thickness of the ohmic contact layer to be less than 200 angstroms, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or working ranges involves only routine skill in the art. The ordinary artisan would have been motivated to further modify Schetzina in the manner described about for at least the purpose of reducing absorption but being thick enough to keep the specific contact resistance below 10^{-2} Ω-cm. In re King, 231 USPQ 136 (Fed. Cir. 1986).

Applicant respectfully traverses the rejections of Claims 6 and 16. The Examiner fails to state where the alleged motivation comes from as there is nothing in Schetzina to suggest that a thickness of less than 200 Angstroms is desirable. The Examiner admits in the rejection of Claims 3 & 13 (see above) that Schetzina does not disclose contact resistance less than $10^{-2}\Omega cm^2$. Therefore, there can be no basis for the Examiner's alleged motivation for reducing thickness in order to reduce absorption yet be thick enough to keep the specific contact resistance below $10^{-2}\Omega cm^2$. The Examiner even fails to state what "general conditions" of these claims are disclosed in the prior art that would have motivated a person of ordinary skill in the art at the time the invention was made to reduce the thickness of 1000 Angstroms by more than 80% to less than 200 Angstroms.

Therefore, Applicants contend that the rejections of Claims 6 and 16 by Schetzina are improper and respectfully request reconsideration and withdrawal of the rejections to Claims 6 and 16 under 35 U.S.C. § 103(a).

Claim 9 is rejected under 35 U.S.C. §103(a) as being unpatentable over Schetzina in view of Yoshida et al. With respect to Claim 9, the Examiner stated that:

> Schetzina discloses the claimed invention except the ohmic contact layer includes Ni and Ag. However, Yoshida et al. discloses the ohmic contact layer including Ni and Ag (column 22, lines 61-65). Thus, it would have been obvious to one of ordinary skill in the art at the time the invention was

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> made to modify Schetzina by including Ni and Ag for the ohmic contact layer as taught by Yoshida et al. The ordinary artisan would have been motivated to further modify Schetzina in the manner described about for at least the purpose of reducing "the contact resistance by about 10% between the contact layer" (column 15, lines 9-11).

Applicants respectfully traverse the rejection of Claim 9. Yoshida et al. discloses that Ni and Ag are additive elements to non-stoichiometric semiconductor compound layer and not metal ohmic contacts (Yoshida et al.; Claims 1& 8; col. 22, lines 12-28 & 61-65). Even so, Claim 8 of Yoshida et al. clearly states that the compound includes only one of the elements selected from the group so either Ni or Ag can be used at any one time but not both. Claim 9 of the instant application clearly claims that the ohmic contact includes both Ni and Ag.

Therefore, Applicants contend that the rejection of Claim 9 by Schetzina in view of Yoshida et al. was improper and respectfully request reconsideration and withdrawal of the rejection of Claim 9 under 35 U.S.C. § 103(a).

Claim 18 is rejected under 35 U.S.C. §103(a) as being unpatentable over Schetzina in view of Okazaki. With respect to Claim 18, the Examiner stated that:

> Schetzina discloses the claimed invention except the ohmic contact layer, which is selected form a group that consists of Ti, Au/NiO, and NiAu. However, Okazaki discloses that the material of the ohmic contact layer (13) is selected from a group of "titanium (Ti), nickel (Ni), etc." (column 8, lines 9-14 and column 8, lines 32-37). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify Schetzina by selecting from a group that consist of Ti, Au/NiO, and Ni/Au for the ohmic contact layer as taught by Okazaki. The ordinary artisan would have been motivated to modify Schetzina in the manner described above for at least the purpose of decreasing the ohmic contact resistance between the layers and increasing the reflectivity of the ohmic contact layer.

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Applicant respectfully traverses the rejection of Claim 18. The Examiner's rejection appears to be based solely on improper hindsight. Okazaki discloses Ti but not Au/NiO or Ni/Au. The Examiner claims that the ordinary artisan would have been motivated to modify Schetzina for at least the purpose of decreasing the ohmic contact resistance between the layers and increasing the reflectivity of the ohmic contact layer (see above). However, neither Schetzina nor Okazaki provides any basis for this, either explicitly or implicitly.

Therefore, Applicants contend that the rejection of Claim 18 by Schetzina in view of Okazaki was improper and respectfully request reconsideration and withdrawal of the rejection of Claim 18 under 35 U.S.C. § 103(a).

CONCLUSION

For the foregoing reasons, Applicant believes pending Claims 1-18 are allowable, and a Notice of Allowance is respectfully requested. The Examiner is invited to call the Applicants' Attorney at (949) 718-5200 for any questions with this response.

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<u>**ATTACHMENT B**</u>

In the following, insertions are boldface type and underlined, and deletions are boldface type and enclosed in brackets.

The paragraph starting on page 6, line 1 is amended as follows

The present invention is a multi-layer contact that consists of multiple material layers providing high reflectivity, low specific contact resistance, and high reliability. Figure 1 shows a cross-sectional embodiment of a semiconductor device 10 with a multi-layer contact 12. The multi-layer contact 12 includes an ohmic layer 12A and a reflective layer 12B. In combination, the ohmic and reflective layers 12A, 12B form a highly reflective ohmic electrical contact to **[the]** semiconductor structure 11. Various optoelectronic semiconductor structures 11 can be used with the multi-layer reflective contact layers 12.

The paragraph starting on page 7, line 27 is amended as follows.

Reflective layer 12B is selected from a group that includes Al, Cu, Rh, Au, Pd, and Ag, alone and any combination. Ag is used in special cases because of electro-migration issues. Al does not electro-migrate as severely as Ag and therefore can be used more reliably in reflective multi-layer contacts.**[.]** Using Al as the reflector, the maximum ohmic layer thickness in the visible region is 150Å for Rh, 200Å for Cu, and 100Å for Au in order to achieve a reflectivity of greater than 75%. Ohmic contact metals that are more absorbing need to be less than 100Å in the visible spectrum. The reflector layer is greater than 500Å thick so that no light will pass through; thus maximum reflectivity is achieved. This layer not only acts as the light reflector but it also will do most of the lateral current spreading, because of the thickness. This is beneficial because the ohmic layer 12A is typically too thin to spread current effectively on its own. Current spreading by a thick reflector layer (>500Å) in

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optoelectronic devices, has many benefits including low V_f (lower spreading resistance). Also, the reflector layer connects any discontinuity in the multi-layer contact created by the surface roughness of the semiconductor structure surface.

The paragraph starting on page 8, line 23, is amended as follows.

Figure 4 illustrates an alternate embodiment of the multi-layer contact 22 to a semiconductor device 20 with multiple contact layers 22A, 22B, and 22C. **Ohmic layer 22A provides ohmic contact to semiconductor 21.** A barrier metal layer 22B interposes the ohmic 22A and reflector layers 22C. The barrier layer 22B is used to prevent diffusion of the ohmic layer 22A into the reflector layer 22C, thus preventing the creation of any inter-metallics. These inter-metallics could degrade the specific contact resistance and reflectivity of the contact and thus the efficiency of the device. This is a reliability issue that should be avoided for long lasting devices. The barrier metal layer should be kept thin, e.g. < 100Å, to minimize light absorption and should be as reflective as possible to contribute to the reflectivity of the contact. Exact metals will vary depending on the ohmic **layer** 22A and **the** reflector layer**[s]** 22C but some candidates include Ni, Co, NiO, Rh, Cr, Pt, Mo, Ti, TiW, WSi, WSi:N, TaSi, TaSi:N, InSnO or TiW:N. The **[contact]** **ohmic** 22A and reflector 22C layers provide the same function as described in the first embodiment.

The paragraph starting on page 9, line 12 is amended as follows.

Figure 5 shows a vertical current LED structure. The multi-layer contact is located on the bottom-side of a LED device 30 that has a conductive substrate 35 so that contacts can be placed on opposing sides of the device creating vertical current (perpendicular to the contacts) paths. **[The]** **A** top contact 31 is either a small area contact or a thin full sheet (not shown) to minimize absorption. The top contact 31 is the electrical contact layer to the n or p-type

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semiconductor layer(s) 32 of the LED. **[The]** <u>**An**</u> active light producing region 33 interposes the top and bottom n or p-type semiconductor layer(s) 32, 34. Either of the multi-layer contacts shown in Figure 1 or 4 may be used with an ohmic contact layer 36, a reflector layer 38, and a barrier layer (for the alternative embodiment) 37.

The paragraph starting on page 10, line 1 is amended as follows.

An alternate configuration for an LED device 40 with multi-layer contacts is shown in Figure 6. The contacts are attached on the same side of the device because **[the]** substrate 41 is non-conductive to create a device that relies on lateral current (parallel to the contacts) to operate. This is made possible by exposing the lower conducting n or p-type layer 42 by etching. The active light-producing region 43 interposes the top and bottom n or p-type layer(s) 42, 44. Either of the multi-layer contact shown in Figures 1 and 4 may be used with an ohmic contact layer 45,48, a reflector layer 47,50, and a barrier layer (for the alternative embodiment) 46, 49.

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ATTACHMENT C

This response amends claims 1, 8, and 11 as follows:

1. (Amended) A light-emitting device comprising:

a heterostructure of semiconductor materials having at least one p**-type** and one n-type layer; and

a p and an n contact, the p contact electrically connected to the p-type layer, the n contact electrically connected to the n-type layer, wherein one of the p and n contacts is a multi-layer contact having at least one ohmic contact layer and one reflector layer.

8. (Amended) A device, as defined in claim 1, wherein the p and n contacts are on opposing faces of the heterostructure.

11. (Amended) A light-emitting semiconductor device comprising a GaN-based heterostructure having at least one p**-type** and one n-type layer; **and**

a p and an n contact, the p contact electrically connected to the p-type layer, the n contact electrically connected to the n-type layer, wherein one of the p and n contacts is a multi-layer contact having at least one ohmic contact layer and one reflector layer.

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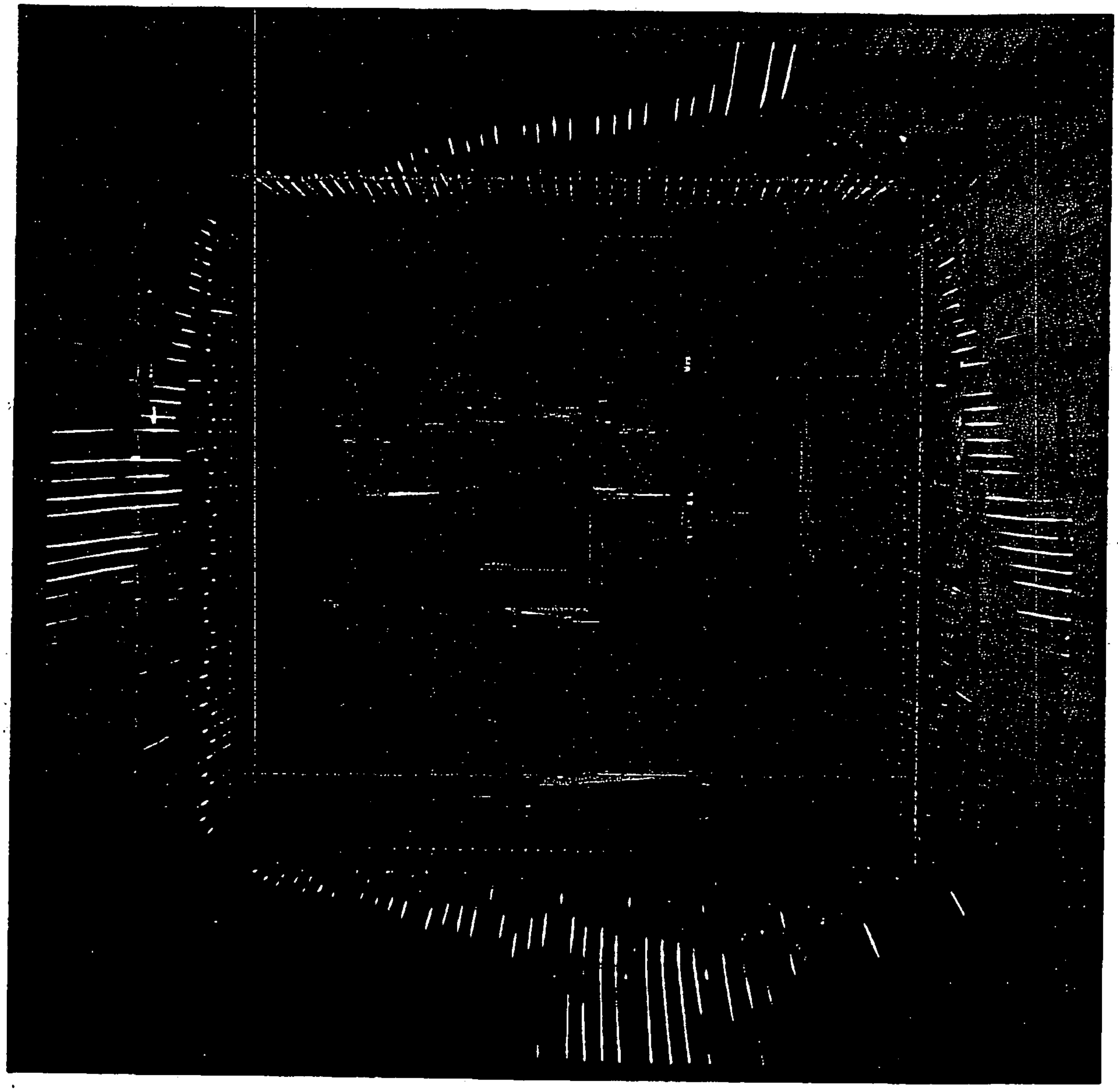
ATTACHMENT D

THIRD EDITION

Solid State Electronic Devices

BEN G. STREETMAN



STREETMAN
THIRD EDITION
Solid State
Electronic Devices

PRENTICE HALL

Prentice Hall Series in Solid State Physical Electronics, Nick Holonyak, Jr., Series Editor

Library of Congress Cataloging-in-Publication Data
Streetman, Ben G.
Solid state electronic devices / Ben G. Streetman.—3rd ed.
p. cm.
Includes bibliographical references.
ISBN 0-13-822941-4
1. Semiconductors. I. Title.
TK7871.85.S77 1990
621.381'52—dc20

89-23175
CIP

Editorial/production: ***Denise Gannon***
Interior design: ***Lee Cohen***
Cover design: ***Lee Cohen***
Cover illustration courtesy of Motorola, Inc.
Manufacturing buyer: ***Donna Douglas***

Printed in the United States of America
10 9 8 7 6 5 4 3

ISBN 0-13-822941-4

Prentice-Hall International (UK) Limited, *London*
Prentice-Hall of Australia Pty. Limited, *Sydney*
Prentice-Hall Canada Inc., *Toronto*
Prentice-Hall Hispanoamericana, S.A., *Mexico*
Prentice-Hall of India Private Limited, *New Delhi*
Prentice-Hall of Japan, Inc., *Tokyo*
Simon & Schuster Asia Pte. Ltd., *Singapore*
Editora Prentice-Hall do Brasil, Ltda., *Rio de Janeiro*

E	energy (J, eV)[†]; battery voltage (V)
E_a, E_d	acceptor, donor energy level (J, eV)
E_c, E_v	conduction band, valence band edge (J, eV)
E_F	equilibrium Fermi level (J, eV)
E_g	band gap energy (J, eV)
E_i	intrinsic level (J, eV)
E_r, E_t	recombination, trapping energy level (J, eV)
$f(E)$	Fermi–Dirac distribution function
F_n, F_p	quasi-Fermi level for electrons, holes (J, eV)
g, g_{op}	EHP generation rate, optical generation rate (cm^{-3}-s^{-1})
g_m	mutual transconductance (Ω^{-1}, S)
h	Planck's constant (J-s, eV-s); Chapter 8: FET channel half-width (cm)
$\hbar$	Planck's constant divided by 2π (J-s, eV-s)
$h\nu$	photon energy (J, eV)
h, k, l	Miller indices
h^+	hole
i, I[‡]	current (A)
I (subscript)	inverted mode of a BJT
i_B, i_C, i_E	base, collector, emitter current in a BJT (A)
I_{CO}, I_{EO}	magnitude of the collector, emitter saturation current with the emitter, collector open (A)
I_{CS}, I_{ES}	magnitude of the collector, emitter saturation current with the emitter, collector shorted (A)
I_D	channel current in an FET, directed from drain to source (A)
I_0	reverse saturation current in a p-n junction (A)
j	$\sqrt{-1}$
J	current density (A/cm^2)
k	Boltzmann's constant (J/K, eV/K)
$\mathbf{k}$	wave vector (cm^{-1})
k_d	distribution coefficient
K	$4\pi\epsilon_0$ (F/cm)
l, L	length (cm)
$\bar{l}$	mean free path for carriers in random motion (cm)
m, m^*	mass, effective mass (kg)
m_n^*, m_p^*	effective mass for electrons, holes (kg)

[†] In the Boltzmann factor $\exp(-\Delta E/kT)$, ΔE can be expressed in J or eV if k is expressed in J/K or eV/K, respectively.

[‡] See note at the end of this list.

m_0
M
$\mathbf{m}, \mathbf{n}$
n
n
n^+
n_i
n_n, n_p
n_0
N (subscript)
N_a, N_d
N_a^-, N_d^+
N_c, N_v
p
p
p^+
p
p_i
p_n, p_p
p_0
q
Q_+, Q_-
Q_d
Q_f
Q_i
Q_{it}
Q_m
Q_n, Q_p
Q_n
Q_{ot}
r, R
R_H
t
t
$\bar{t}$
t_{sd}
T

v, V†	voltage (V)
V	potential energy (J)
$\mathscr{V}$	electrostatic potential (V)
V_{CB}, V_{EB}	voltage from collector to base, emitter to base in a BJT (V)
V_D, V_G	voltage from drain to source, gate to source in an FET (V)
$\mathscr{V}_n, \mathscr{V}_p$	electrostatic potential in the neutral n, p material (V)
V_0	contact potential (V)
V_P	Chapter 8: pinch-off voltage for an FET; Chapter 11: forward breakover voltage for an SCR (V)
V_T	MOS threshold voltage (V)
v, v_d	velocity, drift velocity (cm/s)
w	sample width (cm)
W	depletion region width (cm)
W_b	base width in a BJT, measured between the edges of the emitter and collector junction depletion regions (cm)
x	distance (cm), alloy composition
x_n, x_p	distance in the neutral n region, p region of a junction, measured from the edge of the transition region (cm)
x_{n0}, x_{p0}	penetration of the transition region into the n region, p region, measured from the metallurgical junction (cm)
Z	atomic number; dimension in z-direction (cm)
α	emitter-to-collector current transfer ratio in a BJT
α	optical absorption coefficient (cm^{-1})
α_r	recombination coefficient (cm^3/s)
β	base-to-collector current amplification factor in a BJT
γ	emitter injection efficiency; in a p-n-p, the fraction of i_E due to the hole current i_{Ep}
δ, Δ	incremental change
$\delta n, \delta p$	excess electron, hole concentration (cm^{-3})
$\Delta n_p, \Delta p_n$	excess electron, hole concentration at the edge of the transition region on the p side, n side (cm^{-3})
$\Delta p_C, \Delta p_E$	excess hole concentration in the base of a BJT, evaluated at the edge of the transition region of the collector, emitter junction (cm^{-3})
$\epsilon, \epsilon_r, \epsilon_0$	permittivity, relative dielectric constant, permittivity of free space (F/cm); $\epsilon = \epsilon_r \epsilon_0$
λ	wavelength of light (μm, Å)
μ	mobility (cm^2/V-s)
ν	frequency of light (s^{-1})

†See note at the end of this list

ρ
σ
τ_d
τ_n, τ_p
τ_t
ϕ
ϕ_F
ϕ_s
Φ
Φ_B
Φ_{ms}
ψ, Ψ
ω
$\langle\ \rangle$

Note:
lowercas
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double sub
subscript is
ence V_G −